

We claim:

1. A method of canceling ghost artifacts in magnetic resonance imaging to produce an image or series of images, comprising:

- 5 acquiring data using an array of receiver coils in a magnetic resonance environment, wherein the data is acquired using a phase encode order in which k-space distortion has components which are substantially periodic;
- converting the data to the image domain to produce images with ghost artifacts; and
- 10 canceling the ghost artifacts using phased array ghost cancellation processing to produce an image or series of images with ghost artifacts removed.

2. The method of claim 1, wherein the acquired data is k-space data.

3. The method of claim 1, wherein the converting is achieved using a fast  
15 Fourier transform.

4. The method of claim 1, wherein the phase encode order is designed such that the k-space distortion has a rapid periodic variation, thereby trading what would be a image blurring for image ghosts which can then be cancelled by the phased array  
20 processing method.

5. The method of claim 1, wherein the phased array ghost cancellation processing includes passing the images with the ghost artifacts through one or more phased array combiners coupled in parallel.

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6. The method of claim 5, further including aligning the separated ghost images by shifting the image either prior to phased array combining or following phased array combining.

7. The method of claim 5, wherein the phased array combiners receive an image for each receiver coil and combine the images from the receiver coils into a single image.

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8. The method of claim 5, further including an output combiner coupled to each of the phased array combiners that combines each of the single images received from the phased array combiners into a final output image.

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9. The method of claim 1, wherein using phased array ghost cancellation processing includes using a plurality of phased array combiners coupled in parallel and the method further includes adaptively calculating phased array combiner complex coefficients.

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10. The method of claim 1, further including using a phase encode order that is varied in time to achieve periodic distortion which is time varying in a manner that enables calculating a lower time resolution image without ghost artifacts.

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11. The method of claim 10, wherein a ghost suppressed image is obtained for the purpose of adaptively calculating phased array combiner coefficients for ghost cancellation.

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12. The method of claim 5, further including combining outputs of the phased array combiners together using an output combiner and adaptively computing the output combiner's coefficients as the output combiner is outputting the series of images.

13. The method of claim 1, further including a temporal filter coupled in series with the phased array ghost cancellation processing to further suppress ghost artifacts.

14. A system for canceling ghost artifacts in magnetic resonance imaging to produce a series of images, comprising:

an image reconstructor that receives k-space data and converts the k-space data  
5 to the image domain;

a plurality of array combiners coupled to the image reconstructor, the array combiners being coupled in parallel;

at least one shifter coupled in series between one of the array combiners and the image reconstructor; and

10 an output combiner coupled to each of the array combiners that provides the series of images.

15 15. The system of claim 14, further including adaptively calculating array coefficients for the array combiners.

16. The system of claim 14, further including adaptively calculating combiner coefficients for the output combiner.

20 17. The system of claim 14, further including multiple coils placed near a target to be imaged that receive k-space data representative of the target in the frequency domain and pass the data to the image reconstructor.

25 18. The system of claim 14, wherein the at least one shifter includes a first shifter and further including at least a second shifter coupled in series with an array combiner, the second shifter coupled in parallel with the first shifter.

19. The system of claim 14, wherein the at least one shifter includes  $N_G - 1$  shifters coupled in parallel, where  $N_G$  is a number of ghost artifacts in images produced

by the image reconstructor, each shifter coupled between one of the array combiners and the image reconstructor.

20. The system of claim 14, wherein the array combiners combine images on a  
5 pixel-by-pixel basis and wherein the pixels have a complex weighting.

21. The system of claim 14, wherein the output combiner is a coherent  
combiner and wherein the pixels of the images being combined have a complex  
weighting associated therewith.

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22. The system of claim 14, wherein the array combiners produce a weighted  
image  $h_i(x,y)f(x,y)$ , where  $i$  is an integer number associated with the array combiner.

23. The system of claim 14, further including a temporal filter coupled in series  
15 with at least one of the array combiners to further suppress ghost artifacts.

24. A system for canceling ghost artifacts in magnetic resonance imaging to  
produce a series of images, comprising:

20 means for acquiring data using an array of receiver coils in a magnetic  
resonance environment, wherein the data is acquired using a phase encode order which  
causes k-space distortion to be periodic with a period corresponding to widely spaced  
ghost artifacts;

means for converting the data to the image domain to produce images which  
have ghost artifacts; and

25 means for canceling the ghost artifacts using phased array ghost cancellation  
processing to produce a series of images with ghost artifacts removed.

25. The system of claim 24, further including temporal filtering means coupled in series with the phased array ghost cancellation processing to further suppress ghost artifacts.

5 26. A method for canceling ghost artifacts in magnetic resonance imaging to produce a series of images, comprising:

providing a plurality of array combiners coupled in parallel, each array combiner receiving multiple images associated with receiver coils, each of the array combiners combining the multiple images to provide an output image having complex weights;

10 combining the output images of each of the array combiners; and  
adaptively calculating coefficients needed for the combining of the images.

27. The method of claim 26, further including at least one temporal filter coupled in series with at least one of the array combiners to further suppress ghost  
15 artifacts.

28. A method of canceling ghost artifacts in magnetic resonance imaging to produce an image or series of images, comprising:

20 acquiring data using an array of receiver coils in a magnetic resonance environment, wherein the data is acquired using a phase encode order in which k-space distortion has components which are substantially periodic;

converting the data to the image domain to produce images with ghost artifacts;  
and

canceling the ghost artifacts using at least one phased array combiner that  
25 receives the image domain data and produces an image or series of images with ghost artifacts removed.

29. The method of claim 28, further including a temporal filter coupled in series with the at least one phased array combiner to further suppress ghost artifacts.

30. The method of claim 27, further including adaptively calculating  
5 coefficients for the phased array combiner.

31. The method of claim 28, wherein the data is acquired using a time-varying phase encode order.

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